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ARMOURED VEHICLE TRACK ELASTOMERS - RESEARCH AND DEVELOPMENT AT MRL

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T.E.F. Symes

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T.E.F. Symes

ABSTRACT

The Australian Army employs two basic types of Armoured Fighting Vehicle (AFV) fitted with rubberized (elastomeric) track designs. The *M113* Armoured Personnel Carrier entered Australian service in the 1960's and the *Leopard* AS1 Main Battle Tank in the 1970's. Adoption of elastomeric components in the form of bushings, roadwheel treads, roadwheel pads (roadwheel-side trackshoe pads) and track pads (ground-side track-shoe pads) has provided many improvements in track performance and maintenance requirements. However, the number of such components exhibiting field damage forwarded to MRL for investigation in the early 1980's indicated that the elastomers being used were not optimum for Australian conditions. This paper presents aspects of the work undertaken to improve track elastomer formulations for local industry production and AFV use. australia, (KR...) —

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CONTENTS

ARMOURED VEHICLE TRACK ELASTOMERS - RESEARCH AND DEVELOPMENT AT MRL

1. INTRODUCTION

Both types of Armoured Fighting Vehicle (AFV) employed by the Australian Army, the *Leopard* ASI Main Battle Tank and the *M113* Al Armoured Personnel Carrier, utilize rubber components in the track. So do the variants of these basic AFV's. The adoption of rubber for bushings, roadwheel treads, roadwheel pads and track pads has had many advantages. These include:

(a) reduced wear and fatigue of the metal track components

(b) lower detection signature (noise)

(c) less shock and vibration and hence less crew fatigue and damage to sensitive electronic equipment

(d) improved traction and braking effort (mobility), especially on hard surfaces.

Rea [1] recently reviewed the function of the various track components.

The advantages of using rubber components can be clearly demonstrated by :

(a) comparing the performance of all-metal and rubberized versions of track in the same application

(b) allowing the rubber components to wear beyond safe limits

(c) deliberately removing the rubber track pads [2].

Excessive loss of rubber invariably results in irreparable damage to the metal parts of the track.

The adoption of rubber track components, whilst affording a reduction in Mark I ear detection signature (noise) compared to all-metal track designs, has the disadvantage that hysteretic heating which occurs in the rubber will render detection by thermal imaging equipment easier.

The Australian AFV's normal mode of operation is principally cross-country. Such off-road operation over rough terrain combined with high vehicle speeds causes severe shock loading and subjects the track to the effects of impact with logs, stumps and sharp rocks. High vehicle speeds and extremes of dynamic loading results in a degree of hysteretic heat build-up within the elastomers. Together with levels of solar radiation of up to 1 kW/m^2 and high ambient temperatures, hysteretic heating produces high operational temperatures within the elastomers.

The physical properties of elastomers deteriorate with increase in temperature. When the ultimate strain of an elastomer at operational temperatures is exceeded, by for example local point impact loading, failure of the elastomer occurs by rupture or tearing. Tearing can also occur under dynamic conditions at levels of strain well below that determined as being the value at break by laboratory tension testing.

Australian AFV operational conditions cause failure of track pads and roadwheel treads by cutting, chunking, chunk-out, chipping and tearing mechanisms, as well as loss of adhesion. Bushings however usually fail through stress-relaxation, slippage (migration) and fatigue. Track elastomers do not normally fail by simple abrasion in Australia, although with AFV's driven principally on formed roads they well might.

Cutting and chunking failures are often characteristic of synthetic rubbers and the traditional US preference for synthetic track rubbers can be traced back to World War II. Historical US prejudice against the use of natural rubber is illustrated by MIL-STD-417, which states that "It is the policy of the Department of Defense not to specify natural rubber compositions since this material may not be available in emergencies " [3]. Such restrictions on the choice of elastomer explain the very poor performance of the track pads fitted to a US ***M60*** tank when this vehicle was competitively trialled against ***Leopard*** I in Australia. The policy of forbidding or discouraging the use of natural rubber ignores the superior physical properties of this elastomer, which has been freely available for over 40 years.

MIL-T-11891B [4], used up until recently by the Australian Army to procure ***M113*** bushings and currently still used to procure ***M113*** roadwheel pads and track pads, allows the use of natural rubber for bushings only. Pads are to be of synthetic rubber. MIL-T-3100B [5], used to procure ***M113*** roadwheels, also nominates synthetic rubber.

Although it has not been possible to obtain any rubber technology information from the makers of the ***Leopard*** AS1 Main Battle Tank, Krauss Maffei, MRL has found that ***Leopard*** bushes are of natural rubber, the pads may be of synthetic or natural and the roadwheels are of synthetic rubber. European and US manufacturers of AFV's do not therefore agree as to the most appropriate elastomers to be used in track components. In addition, Australian AFV's are not generally required to be proficient in cultivating asparagus beds or at autobahn racing events.

The policy of the Australian Army in clinging to the use of US specifications for track rubbers has been and still is questioned by MRL [6]. Possible difficulties which would be caused by hostile disruption to the importation of natural rubber could be minimised by Army tasking MRL to maintain a data base for track elastomers applicable to the compounded optimization of the synthetics made in Australia, Styrene Butadiene and Butadiene Rubbers (SBR and BR). These synthetics find their principal application in passenger car tyres. I foresee that natural rubber would still be needed for bushings, even in a time of dire emergency, however development and maintenance of a suitable data base would minimise the deleterious effects in the event of being forced to use synthetics in the other track applications. Bushings are a relatively small consumer of rubber.

Since no natural rubber is produced in Australia, the policy of considering the disposal (or having disposed) of the Australian National Stockpile of natural rubber is thus a cause for serious concern. A very large stockpile of natural rubber and other strategic materials is maintained by the US Government. Much interest in the production of "Guayule", a type of natural rubber, from the semi-arid-climate shrub *Parthenium argentatum* which is endemic to South America, exists in the US. Quantities of *Parthenium argentatum* were grown in South Australia during World War II (but not harvested because of the cessation of hostilities), however some State Governments as well as the CSIRO have again expressed similar interest in the cultivation and processing of Guayule in Australia.

Serious problems with the Abrams M1 tank track rubbers, widely publicised in the US and World press and international journals, have also aroused concern in the US over the policy of nominating which elastomers are permissible, rather than basing selection on performance criteria [7]. In cognizance of this criticism, US MIL Specifications for track elastomers are now undergoing very rapid evolution [8, 9, 10] and are based on performance characteristics.

Problems with M1 track are associated with hysteretic heating of the thick synthetic rubber sections used, the relatively poor thermal conductivity of rubber and the track pads being of a non-replaceable design. Many millions of US dollars have been spent attempting to resolve problems with the M1 track rubbers.

In recent years at least, a shortage of serviceable *M113* track appears to have become almost a tradition in Australia. Excessive rates of track failure involve major expense, create a logistic and downtime burden [11] and could have very serious effects on the availability of AFV's deployed to remote areas.

2. WORK UNDERTAKEN

The Army sponsored MRL track elastomers research task, commenced in 1983 [12], was designed so as to identify the factors which cause the modes of failure prevalent in Australia. Compound optimization was undertaken to develop elastomers specifically tailored for Australian AFV operational conditions by means of the following elastomer assessment methods:

a. ultimate stress at ambient and elevated temperatures
b. ultimate strain at ambient and elevated temperatures
c. modulus at incrmements of 100% strain
d. hardness
e. tear strength at ambient and elevated temperatures
f. stress relaxation and compression set
g. cut growth and flexing fatigue
h. abrasion resistance
i. hysteresis loss (heat build up)
j. ageing behaviour
k. bond strength (adhesion) to steel and aluminium.

The need to achieve a satisfactory compromise of critical properties, such as those of hysteresis and tear characteristics, was appreciated at the commencement of the program. Hysteretic behaviour, in conjunction with limited field trial measurements, was used to estimate actual operating temperatures of developmental compound elastomeric components.

3. LABORATORY FINDINGS

Extensive laboratory mixing, moulding and testing was initially used to assess the potential suitability of elastomer compounds. SBR and BR, either alone or as blends, were confirmed to have very good abrasion resistance however the tear strength, particularly at elevated temperatures, was not as good as that of natural rubber. SBR and BR also showed a more severe loss in physical properties with increasing temperature than natural rubber. Of great importance is the observation that natural rubber underwent less hysteretic heat build-up than SBR or SBR/BR blends.

There is thus an analogy between the types of elastomers appropriate for highway or off-road pneumatic tyre treads and AFV track pads. SBR and BR are used for passenger car tyre treads intended for highway use and so are likely to continue to be suitable for light AFV's, such as the *M113*, when operated only on formed roads. Natural rubber is used for heavy-duty truck tyres where hysteretic heat build-up on the highway or cutting and chunking when operated off-road are likely problems. The above analogy and our laboratory results confirm that natural rubber is the more appropriate track elastomer for heavy AFV's, such as *Leopard* I, or where off-road operation predominates.

3.1 Bushings

Natural rubber is and has been traditionally the best elastomer for bushings. This is recognized even in old MIL specifications such as MIL-T-11891B [4], which were drawn up when the bitter memories of acute natural rubber shortages caused during World War II were still prominent [3].

Natural rubber compounds were optimized for bondability to steel and resistance to stress-relaxation and fatigue. A suitable compromise between stress-relaxation characteristics and fatigue life had however to be derived. Several types of carbon black filler gave good results. Fine-particle-size low-structure blacks gave good fatigue life whereas larger-particle-size high-structure blacks produced lower set and stress-relaxation results.

Surprisingly, a number of protective agents commonly used by rubber manufacturers to improve the ozone and flex-cracking resistance of rubber were found to exacerbate slippage and migration of force-fitted bushings. Circumferential slippage destroys the as-assembled offset allowance effected at Small Arms Factory (SAF), Lithgow and promotes premature failure. Lateral migration makes dismantling and reassembly of the track difficult. Excessive migration makes it impossible to service track in the field because of the need to then destroy track shoes by use of an oxy-acetylene torch, cutting equipment which the vehicle crews do not have available.

3.2 Roadwheel Treads

Because current track designs facilitate the injection of trash between the roadwheel tread and running surface on the back of the trackshoe, good tear strength was considered to be an important requirement for roadwheel treads. Low hysteretic heat build-up was also desirable.

The original roadwheel treads on both the *Leopard* and *M113* AFV's were confirmed to be of SBR synthetic rubber. Laboratory development work indicated that natural rubber treads reinforced with either carbon black or silyltetrasulfide modified large-particle-size silica would be more appropriate for Australian conditions.

3.3 Track Pads

Similar design parameters to those used for roadwheel treads were employed. It was felt however that because track pads directly contact rough terrain the most important requirement was very high tear strength at operational temperatures. The original *Leopard* pads were of synthetic rubber as are those of the *M113* APC and the US *M60* tank. In response to severe problems with *Leopard* synthetic rubber track pads in Australia, natural rubber pads were subsequently supplied by Diehl, a German manufacturer.

A number of original "Star" brand pads (of SBR synthetic rubber) can still be found amongst Australian stocks of *Leopard* track pads. Although the Diehl natural rubber pads were thought to be somewhere near optimum for Australian conditions, natural rubber pad compounds reinforced with silyltetrasulfide modified fine-particle-size silica compounds have shown even more promise [13].

4. CORRELATION BETWEEN LABORATORY RESULTS AND FIELD PERFORMANCE

The bane of the rubber technologist is the often poor correlation between laboratory test results and actual field performance. Even the multinational tyre companies with their huge resources elect to confirm laboratory data by undertaking extensive road trials. Such trials utilize only professional drivers having extensive experience and hence well established and reproducible driving "techniques". Even so, considerable variation in results driver-to-driver are often observed. This can even occur on the same sections of roads. Careful analysis of the trials results is necessary to justify the adoption of the laboratory data for production tyres.

It is obviously impossible to use reproducible driving techniques or terrain types for the tr[illegible] f AFV elastomers under Australian conditions. Consequently, comparison of t[illegible] performance of MRL candidate formulations with original equipment components fitted at the same time to stations subjected to similar levels of stress on the same test vehicle or group of test vehicles is most likely to offer a good guide to durability.

The DIN "trouser" tear test and the DIN abrasion test machine appear to give satisfactory correlation with roadwheel tread and track pad performance in the field. Modifications to the "Heat Generation and Flexing Fatigue in Compression" procedure and equipment described in Method A of ASTM Standard Test Method D623 have allowed workable estimates of field temperatures to be made. These estimates provide likely temperature increment above ambient and fatigue characteristics data for roadwheel tread and track pad elastomer compounds. Although this modified procedure is only applicable to the heat build-up and fatigue of laboratory moulded bushing compound specimens, roadwheel tread and track pad compounds can be assessed using specimens that are either cut from moulded components or are laboratory moulded. ASTM D623 has also proved to be useful for state-of-cure investigations and for assessing the quality of finished products of thick section.

5. TRIALS STRATEGY

Because of funding difficulties and vehicle mileage constraints, dedicated trials have proved to be difficult to undertake in Australia. The approach which has thus been adopted is to compare the performance of candidate compounds against that of the original components. This has been done in conjunction with Army Maintenance Engineering Agency (MEA) on the basis of regularly monitoring performance during normal AFV operation and involves the fitting of mixed sets of roadwheels or sections of track containing trial components. Such an approach is the best compromise in view of the necessarily limited number of components that can be trialled. Preference has been given to employ AFV's that are likely to be used for driver training or to take part in extended exercises, particularly in inland or northern Australia. Such AFV's accumulated mileage at a greater rate than others. These preferences however necessitated moving track from one AFV to another.

Extended periods of hot weather can also be expected to exacerbate any deleterious effects on performance. In addition, because *Leopard* I components are the more highly stressed, it is considered that formulations which prove to be satisfactory on *Leopard* are also likely to be satisfactory on the *M113*, at least under cross-country operational conditions.

The prototype developmental formulation trials components were all, with the exception of roadwheels and *Leopard* pins which were too big for the available press, initially moulded at MRL. This was done to confirm the good processability of the formulations and to provide small numbers of trials components. MRL is unable to fund the acquisition of large quantities of mixed rubber or moulded trials components.

6. TRIALS RESULTS

6.1 *M113* Bushings

Mouldings made at MRL from MRL formulation 1452/4 were monitored on several vehicles. Superiority over the standard bushings was demonstrated after as little as 1600 km, particularly with vehicles involved in Exercise Arnhem Phoenix conducted during April 1985 in Arnhem Land, Northern Territory. Two of the 7 link sections of track involved were subsequently trialled on a 2 CAV Tracked Load Carrier variant of the *M113* (Vehicle Number ARN 17709, Call Sign "55 Charlie") at Shoal Water Bay Training Area (SWBTA) during Exercise Tasman Warrior in October 1985.

MRL formulation 1452/4, which does not contain any ozone protective additives [14], was nominated for all Australian produced *M113* bushings in June 1986. The draft Specification [15] used as an enforceable [16] purchase document for bushings since that time was derived using a considerable amount of technical input from MRL [17].

A quantity of production T130 track shipped direct from SAF, Lithgow to 1st Armoured Regiment, Puckapunyal, Victoria (1AR) was also monitored by MEA. Bushings of MRL formulation 1452/4 - identifiable by the "M" brand - were still satisfactory after 1700 km, whereas those of British Tyre and Rubber Company, Auburn, New South Wales (BTR) formulation 1695 (supplied to SAF for many years) were unsatisfactory after only 298 km [18]. The push-out force necessary to induce migration in MRL 1452/4 bushes was found to be consistently higher when compared with BTR 1695 bushings [19].

These observations confirm the superiority of MRL 1452/4 bushings and tend to validate the laboratory developments achieved. For example, BTR 1695 bushings were found to last about 2 hours on an MRL developed fatigue test machine whereas MRL 1452/4 bushings last about 24 hours [20]. The importance of ensuring adequate trackshoe borehole cleanliness prior to the force-fitting assembly of bushings has been stressed by MRL many times [e.g. 18, 19, 21]

6.2 *M113* Roadwheels

No developmental natural rubber *M113* roadwheels have been moulded or trialled. Justification for doing so is however provided by the improvement in performance already achieved with *Leopard* roadwheels [22, 23]. Original *Leopard* and *M113* roadwheels are of SBR synthetic rubber. I have previously recommended the production and trial of natural rubber *M113* roadwheel treads [24, 25].

Since the injection moulding process gives better state-of-cure and physical properties uniformity than compression moulded thick rubber sections, I again recommend that not only should natural rubber *M113* roadwheel treads be trialled, but that they should be injection moulded natural rubber [25]. It may be possible to fund this requirement through Defence Industry Development Branch (DIDB) as was the case in developing an Australian capability for the refurbishment of *Leopard* roadwheels. Transfer moulding, which imparts most of the benefits of injection moulding, is also worth consideration as an alternative production method.

6.3 *M113* Track Pads

Good results have been obtained with silyltetrasulfide modified fine-particle-size silica reinforced natural rubber pad formulations. These pads, transfer moulded at MRL, were fitted to *M113* Vehicle Number 134 178 during Exercise Tasman Warrior held at SWBTA in 1985 and ran considerably cooler. The lower operational temperatures of the natural rubber pads compared to the SBR pads produced and supplied to Army for many years [4] confirms the laboratory identified superior hysteretic behaviour of natural rubber. By way of illustrating some of the difficulties associated with the necessity of undertaking non-dedicated trials of track components in Australia, the whereabouts of these pads is not now known.

Additional MRL pads of natural rubber and a blend of natural rubber and the synthetic BR were fitted to *M113's* at 1AR and observed by MEA. After 960 km a few of these together with some standard SBR pads [4] were returned to MRL. It is assumed that the rest were lost because of the poor fatigue life of the lightweight steel backing plates, adopted from a US design for Australian production without trial, and supplied to MRL by SAF, Lithgow. Although a small amount of chipping was present on the leading edge of the all natural rubber pads, the massive chunking characteristic of the SBR pads was absent.

Partial replacement of natural rubber with BR improved the abrasion resistance and pads made from this blend of elastomers should perform satisfactorily when used principally on sealed and formed gravel roads [26].

6.4 *Leopard* Bushings

The production of all-new *Leopard* track in Australia (at SAF, Lithgow) is still apparently at the prototype stage. Some track has however been refurbished. Cracking problems were experienced with the original soft German pins [1], consequently bushing trials were conducted in conjunction with the assessment of SAF produced induction

hardened pins. MRL formulation 1452/4 was proved to be superior to the BTR 1695 formulation supplied to MIL-T-11891B and previously used over many years for *M113* bushings [4]. After 1700 km all of the BTR 1695 bushed pins (branded "A") had to be removed because of excessive stretch (growth). Track which has grown may be compensated for by removing one or two links, but changes in pitch centre-distance when more than this number of links have to be removed can cause problems with the drive sprockets.

Attempts to determine the ultimate life of the MRL formulation *Leopard* bushings were continually frustrated by metallurgical failures of the worn components used in the refurbished track. For this reason, trials of the refurbished track had to be terminated before the bushings had failed.

For new track, it does however appear reasonable to expect a life of up to 6000 km for bushes and more than 7800 km for the metal parts of the track [27]. Correct maintenance procedures for the track must however be ensured at all times for these figures to be achieved.

Since *Leopard* track operates at higher levels of stress, I do not recommend that an elastomer formulation for *Leopard* bushings be accepted on the basis of the performance of that formulation in *M113* track.

Because of the difficulties already experienced with used components having poorly matched extents of wear as were used in the refurbished Australian track, I recommend that further trials of Australian bushes be held over until all-new Australian track is available. Alternatively all-new German track could be disassembled, the boreholes cleaned and then fitted with Australian bushed pins.

6.5 *Leopard* Roadwheels

Carbon black reinforced natural rubber roadwheels of two proprietary formulations moulded by BTR for trial purposes all failed prematurely because of adhesion problems. BTR management blamed disgruntled factory staff. Investigation by MRL revealed poor "housekeeping" with the bonding procedure in the contractor's works. Adhesion problems were also exacerbated by the type of formulation used. We have found semi-efficient or efficient-vulcanization systems to be difficult to bond compared to those of conventional sulfur level. High levels of antiozonants can also cause problems. The roadwheels moulded by BTR had been refurbished using a "spray-on" hard metal wear strip applied by Ordnance Factory, Maribyrnong (OFM).

Dunlop Aviation of Bayswater, Victoria also refurbished some trial roadwheels using a bolt-on mild steel wear strip of their own design. These wheels were rerubbered using carbon black reinforced natural rubber by an associate company, Dunlop Industrial (their compound No AV130) acting as a subcontractor to Dunlop Aviation. Wheel performance was variable. Poor "housekeeping" with the bonding procedure was again identified as a problem, and because of moulding faults, some of the surviving wheels operated at higher than desired internal temperatures during a road-run. Further investigation revealed that although six batches of rubber were needed to fulfill the order, only five were actually qualified at MRL. A sample of rubber, extruded as a method of preparing preforms for moulding, was subsequently examined. The physical

properties of this lot of rubber did not match those of the original AV130 samples and chemical analysis identified the presence of a fatty acid amide, hydrocarbon wax and octylated diphenylamine [28]. None of these substances was authorized for use in AV130. Additionally, "Santoflex 13", an important flex cracking inhibitor/antioxidant/antiozonant nominated in the formulation, was absent.

The roadwheels originally refurbished by OFM and retreaded by BTR, which failed by premature rubber loss, were again retreaded but by Baron Rubber of Coburg, Victoria. Two natural rubber formulations were used. The carbon black reinforced formulation gave irregular tread retention results however all of the silyltetrasulfide modified silica formulation MRL 1433D roadwheels were still satisfactory after 2740 km [22]. By comparison, the German roadwheels used for reference had failed at 1900 km.

Baron Rubber also rerubbered the roadwheels originally refurbished using the bolt-on design of wear strip by Dunlop Aviation. Two formulations were used, one based on fine particle-size low-modulus silica (MRL 1435G) and the other on medium particle-size high-modulus silica (MRL 1433D/1, a green coloured variant of the previously successful formulation MRL 1433D). These wheels were also compared with the performance of those from Germany. Compound MRL 1433D/1 clearly performed the best [29]. This trial also confirmed the advantage in using a bonding junction stock developed at MRL [30] to effect reliable adhesion.

6.6 *Leopard* Track Pads

Conventional natural rubber pad formulations were found to be superior to the original Star brand SBR pads and similar to the replacement Diehl natural rubber pads. Additional pads for trial were also obtained from BTR through SAF. These comprised BTR's mix of the natural rubber formulation MRL 1387A as well as the SBR stock BTR 2615 currently used for *M113* pads. Tear strength of stock BTR 2615, particularly at elevated temperatures, is relatively poor [31]. The vehicle to which these pads were fitted appeared to spend lengthy periods in the workshop, and the only information available is that after only 194 km the BTR 2615 pads were badly chunked.

Further *Leopard* pads were transfer moulded at MRL. These were of three formulations [22]:

(a) natural rubber reinforced with carbon black (MRL 1500G)

(b) natural rubber reinforced with silyltetrasulfide modified fine particle-size silica (MRL 1476C)

(c) natural rubber/BR blend reinforced with silyltetrasulfide modified fine particle-size silica (MRL 1476B).

Fitted to vehicle number 27760, the MRL 1500G pads gave similar operational temperature results to the Diehl pads during a road-run trial. Formulations 1476B and C however gave lower operational temperatures. MEA later reported that the German track pads used for comparison "have already been replaced once, and the second set are currently worn to the same limits as the trial pads" [32]. Whilst it is not clear which

formulation pads are being referred to, it is probable that they are either of MRL 1476B or C, since the new technology employed in the development of these formulations permitted them to be coloured green and hence they are readily identifiable.

At the request of SAF, the formulations used for the above trial pads were provided to Mackay Rubber of Moorabbin, Victoria on 25 May 1986 [33] so as to permit moulding of off-tool samples of all-Australian pads. These were to utilize special steel for inserts procured by SAF from Germany and provided to Mackay "in-aid". Difficulties were experienced by Mackay in stamping-out the inserts, however rubber moulding trials are expected to be carried out in December 1987.

7. CONCLUSIONS

Natural rubber has been demonstrated to be the most suitable track component elastomer for Australian AFV operations. The extensive investigations undertaken with polyurethane elastomers in the US have not yet identified a satisfactory material for track applications.

Different formulations are necessary for bushings, roadwheel treads and pads. The same formulation is suitable for roadwheel pads and track pads. Roadwheel pads, however, are the less severely stressed because of "shape factor" restraints imposed by the shoe forging profile.

Data obtained from the somewhat limited trials undertaken to date confirms that the best performance was obtained when compounds were specifically optimized to suit the arduous conditions encountered with the normal modes of AFV operation in Australia.

Compounds which perform well on *Leopard* should also perform satisfactorily in similar applications on *M113's* when driven principally off-road.

Improvements in the dynamic adhesion of roadwheel treads have been achieved by the use of bonding junction stock formulation MRL 1512I.

8. RECOMMENDATIONS

8.1 *M113* Bushings

The forthcoming formal trial of BTR 1695 and MRL 1452/4 formulation bushings, to be undertaken by EDE at Monegeeta, should be expedited if at all possible. A successful trial result will confirm the validity and applicability of the laboratory tests

nominated in the Draft Specification [16] and permit formal acceptance of this document as an enforceable purchase specification. This matter is of importance because of the necessity to ratify the suitability of other contractors' offerings. SAF are keen to obtain alternative sources of supply.

8.2 *Leopard* Bushings

Because of the difficulties already experienced with used components poorly matched for wear extent in refurbished track, larger scale trials of Australian bushes should be held over until all-new Australian produced track is available. *Leopard* track operates at higher levels of stress than is the case with the *M113*, consequently I do not recommend that a bushing formulation for *Leopard* be accepted as satisfactory on the basis of the performance of that formulation in either "A" or "E" type T130 track.

Satisfactory trials with bushings of formulation MRL 1452/4, or any other formulation yet to be identified, in *Leopard* track would permit the Draft Specification [16] not only to be accepted as valid, but to be adopted as a Specification for bushing applications for all AFV's in the Australian inventory.

8.3 *Leopard* Roadwheels

The current recommendation for the tread of *Leopard* roadwheels is MRL formulation 1433D. Moulding, however, should be undertaken in conjunction with bonding junction stock MRL 1512I applied across the entire bonded face of the roadwheel tread.

8.4 *M113* Roadwheels

Arrangements should be made to procure and trial a statistically significant number of transfer or injection moulded *M113* roadwheels using formulation MRL 1433D as the tread elastomer.

8.5 *Leopard* Track Pads

Trials of the all-Australian new *Leopard* track should use transfer moulded pads of formulation MRL 1476C.

8.6 *M113* Track Pads

Arrangements should be made to procure and trial a statistically significant number of transfer or injection moulded formulation MRL 1476C track pads using sufficiently robust backing plates.

8.7 *Leopard* and *M113* Roadwheel-Side Trackshoe Pads

Because of the geometric support offered by the trackshoe cavity design, any properly bonded premium quality abrasion resistant engineering rubber should be suitable. Track pad formulations are certainly appropriate, however SAF experienced difficulty in achieving satisfactory state-of-cure and adhesion with *Leopard* trackshoe pads moulded from the *M113* trackshoe stock BTR 2615 [34].

8.8 Production and Assembly Aspects

Provision of optimized rubber formulations alone does not guarantee successful performance. MANUFACTURING PROCESSES FOR TRACK ELASTOMERS MUST BE RIGIDLY CONTROLLED AT ALL STAGES OF PRODUCTION AND ASSEMBLY. In particular, every effort must be made to ensure optimum state-of-cure as well as adequate levels of rubber-to-metal adhesion. Boreholes of trackshoes, for example, require particular attention prior to force-fitting bushes.

Once attempts at bonding have been effected, poor preparation or contamination of the surfaces to be bonded cannot be detected by non-destructive methods. Component failure, unfortunately, then only confirms that adequate quality control has not been effected satisfactorily.

8.9 Supply Matters

Many materials (elastomers, compounding ingredients, adhesives) used for elastomeric track components are imported. Army should task MRL to develop and maintain a data base with the objective of updating a capability to recommend manufacturing processes and formulations with as high an indigenous content as is possible.

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ABSTRACT

The Australian Army employs two basic types of Armoured Fighting Vehicle (AFV) fitted with rubberized (elastomeric) track designs. The M113 Armoured Personnel Carrier entered Australian service in the 1960's and the Leopard AS1 Main Battle Tank in the 1970's. Adoption of elastomeric components in the form of bushings, roadwheel treads, roadwheel pads (roadwheel-side trackshoe pads) and track pads (ground-side track-shoe pads) has provided many improvements in track performance and maintenance requirements. However, the number of such components exhibiting field damage forwarded to MRL for investigation in the early 1980's indicated that the elastomers being used were not optimum for Australian conditions. This paper presents aspects of the work undertaken to improve track elastomer formulations for local industry production and AFV use.